Bell Laboratories **RECORD**

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Cover *Magnetic yttrium iron garnet crystals spill out of platinum crucible in which they were synthesized. X-ray photographs yield film strips from which graphs and structural models can be made. Natural garnet in foreground serves as pedestal for Garnet Rose. (See story on page 81)*

Tracking and Communications Network Vital To Glenn's Orbital Flight

America's biggest day in space—last month's three-orbit flight by John Glenn—was made possible by the National Aeronautics and Space Administration industrial team that included Western Electric and Bell Telephone Laboratories. After the successful launching, flight, and recovery of Colonel Glenn, NASA officials reported that "tracking and telemetry were beautiful" and that "plot boards showed the smoothest tracking" of any Project Mercury mission.

The vast 18-station tracking and communications network was built for NASA by five companies which were led by the Western Electric Company. Bell Laboratories served as consultant on all technical phases of the project and was responsible for systems analysis and test planning. In addition, the Laboratories supervised the design of the Mercury Command and Control Center at Cape Canaveral and developed a simulator for training the Mercury flight controllers (RECORD, *October*, 1961).

The tracking and instrumentation system followed Glenn with radar and collected and transmitted telemetry data covering nearly 100 items, including environment in the capsule and the astronaut's physiological condition. This information was funneled into the Goddard Space Flight Center at Greenbelt, Maryland, the computer and communications hub of the entire network. Here high-speed computers and switching equipment organized and relayed this information to the Mercury Control Center.

Cape Canaveral is the focal point for all the information gathered by the stations in the tracking network. Sixteen of the eighteen stations serve as collection points for data on the condition of the astronaut and the capsule. Six of the ground stations are also equipped to control certain flight operations or events within the capsule.

The tracking and information system offers essentially continuous, two-way radio contact with the orbiting capsule; for talking with the astronaut, for receiving telemetry of instrument readings in his spacecraft and for controlling remotely certain flight equipment in the capsule. These radio links use one channel in the HF range between 15 and 30 megacycles and three in the UHF range of 200 to 300 megacycles.

The system also has a world-girdling network of communication circuits for voice, teletype and data transmission between stations. Leased facilities of communications carriers in many lands are used as well as a wide variety of communication techniques. These facilities include land lines, submarine cables, microwave and HF point-to-point radio systems and both wire and radio carrier arrangements.

Extent of Communications Network

Altogether the communication facilities comprise some 35,000 miles of voice channels interconnecting 13 sites; 96,400 circuit miles of teletype channels connecting all sites (this circuit also transmits radar data from 13 sites); and 5,500 circuit miles of high-speed data transmission channels between Canaveral and Goddard Space Flight Center. A significant achievement of the Laboratories engineering effort was the development of a system that handled vast amounts of data, generated at points sometimes separated by the entire world, in essentially "real time"; that is, nearly instantaneously.

The Mercury capsule is tracked by radar for the entire period of *powered* flight and as it passes within range of radars at eleven of the sites. Radar data flows by automatic teletype connection directly into electronic computers at Goddard. The computers maintain a continuous "estimate of present position" of the spacecraft and predict when and where it will arrive for succeeding sites. These "acquisition messages" are originated by the computer and are teletyped automatically to remote sites.

Approximately 37 quantities vital to the success of the mission are derived from the computers and transmitted over high-speed data channels